Fisheries and Oceans Canada | Pêches et Océans Canada
Science | Sciences

C S A S | **S C C S**

Canadian Science Advisory Secretariat | **Secrétariat canadien de consultation scientifique**

Research Document 2007/004 | **Document de recherche 2007/004**

Not to be cited without permission of the authors * | Ne pas citer sans autorisation des auteurs *

Area 9 Herring: a review of available information for stock assessment purposes

Hareng de la zone 9 : Examen de l'information disponible aux fins de l'évaluation des stocks

Thomas W. Therriault

Fisheries and Oceans Canada
Pacific Biological Station
Nanaimo, BC V9T 6N7

* This series documents the scientific basis for the evaluation of fisheries resources in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

* La présente série documente les bases scientifiques des évaluations des ressources halieutiques du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

Research documents are produced in the official language in which they are provided to the Secretariat.

Les documents de recherche sont publiés dans la langue officielle utilisée dans le manuscrit envoyé au Secrétariat.

This document is available on the Internet at: Ce document est disponible sur l'Internet à:
http://www.dfo-mpo.gc.ca/csas/

ISSN 1499-3848 (Printed / Imprimé)
© Her Majesty the Queen in Right of Canada, 2007
© Sa Majesté la Reine du Chef du Canada, 2007
Canada

2008-04794/

Abstract

Area 9 is located outside of the Central Coast major herring stock assessment region and includes all of Rivers Inlet. Pacific herring (*Clupea pallasi*) often are observed in this area but have not been harvested from this area since the reduction fishery that ended in the late 1960s. Some stakeholders have requested harvest opportunities in this area and a review of available information was conducted to provide scientific advice on the feasibility of this request. A review of the population genetic information suggested potential differences from the Central Coast stock but additional years of data are required to confirm this possibility. A review of the catch information was relatively uninformative because all landings were from the reduction fishery period when herring were fished almost year round, often off their spawning grounds. Also, this fishery was plagued by mis-reporting of landing locations that further compromises the limited information available. A review of the spawn data showed the patchiness of this time series and high variability. Also, there was a change in methodology from surface to dive surveys to quantify herring spawn. Average biomass based on observed spawn was around 500 tonnes with a median around 260 tonnes, a level unlikely to sustain any directed fishery. Also, the distribution of spawn was variable among Sections and Beds in Area 9 such that resolution of stock structure was not possible based on spawn. Thus, based on the limited data currently available, it was not possible to recommend harvest opportunities be entertained at this time. With the collection of additional spawn and biosampling data future harvest might be considered in this area if population genetics confirm Area 9 herring are genetically different from the Central Coast herring population and escapement data suggests a sustainable level of biomass exists in Area 9 that could support a harvest.

Résumé

La zone 9 se situe en dehors de la principale région d'évaluation des stocks de hareng de la côte centrale et englobe la totalité de l'inlet Rivers. Le hareng du Pacifique (*Clupea pallasi*) est souvent observé dans ce secteur, mais il n'y a pas été exploité depuis la pêche de réduction qui a été interrompue à la fin des années 1960. Certains intervenants ont demandé des possibilités de pêche dans cette zone, de sorte qu'un examen de l'information disponible a été entrepris afin de fournir des avis scientifiques sur la possibilité de donner suite à cette demande. Un examen de l'information génétique relative à la population révèle des différences possibles par rapport au stock de la côte centrale, mais il faudrait analyser les données de quelques années additionnelles pour confirmer cette éventualité. L'examen des données sur les prises n'a pas donné beaucoup d'information, car tous les débarquements datent de l'époque de la pêche de réduction, quand le hareng était pêché pendant presque toute l'année, souvent en dehors de ses frayères. De plus, cette pêche est connue pour avoir fait l'objet de déclarations erronées des lieux de débarquement, ce qui nuit encore davantage à la valeur de l'information limitée. L'étude des données sur la ponte a montré l'inégalité de cette série chronologique et de fortes fluctuations. De plus, on constate un changement dans la méthode utilisée pour la quantification des œufs de hareng qui, d'un relevé de surface est devenue un relevé en plongée. La biomasse moyenne, d'après les œufs observés, était d'environ 500 tonnes avec une médiane de 260 tonnes à peu près, niveau qui pourrait difficilement soutenir une pêche dirigée. De plus, la répartition des œufs variait selon les sections et les frayères de la zone 9, au point où il n'a pas été possible de déterminer la structure du stock en fonction des œufs. Ainsi, à partir des données limitées actuellement disponibles, il a été impossible de recommander des possibilités de pêche réalisables actuellement. La collecte de données additionnelles par bio-échantillonnage et relevé des œufs pourrait permettre d'envisager une pêche dans cette zone si l'information génétique de la population confirme que le hareng de la zone 9 est génétiquement différent de la population de la côte centrale et si les données sur l'échappée révèlent que la biomasse de la zone 9 peut soutenir une pêche.

Introduction

In British Columbia, Pacific herring (*Clupea pallasi*) are distributed coastwide, including offshore locations and continental inlets. Currently, DFO recognizes five major and two minor herring stocks for management purposes and a maximum harvest level is determined for each of these stocks annually through the existing Pacific Scientific Advice Review Committee (PSARC) process. The five major herring stocks, Queen Charlotte Islands (QCI), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SOG), and West Coast Vancouver Island (WCVI) are migratory with stock assessment boundaries determined by winter spawning locations (Haegele and Fitzpatrick, 1983; Schweigert, 2005) (Figure 1). In addition, two minor herring stocks, Area 27 and 2 West, also are recognized (Figure 1). Although herring are found outside of these areas, no harvest opportunities currently exist for these fish.

The Wui'kinuxv First Nation have requested harvest opportunities for herring in Area 9 and DFO committed to a scientific review of available information in an attempt to determine if this request is feasible. DFO Science was requested to conduct this review as part of the PSARC process (Appendix 1). Area 9 is not currently part of the CC major assessment area (Figure 1) thus herring in this area are not available for harvesting. Further, as DFO is committed to the Precautionary Approach (PA), any potential harvest opportunities need to be consistent with this position. The PA for fisheries management attempts to conserve stocks by using scientific advice to evaluate harvest strategies (FAO, 1995). Also, management plans need to have clear objectives and include efforts to monitor and assess the effects of harvesting on a stock. Data-limited situations confound application of the PA as extensive data is normally a prerequisite for providing scientific advice (Therriault and Hay, 2005). In general, in the absence of detailed stock assessment information, a conservative approach to potential harvest is suggested. The biological review conducted here represents the first step toward this objective. Although this review only includes data collected for Area 9, the general framework should have broad applicability to other "minor" herring stocks or other fisheries where data is limited and harvest opportunities are being considered for the first time.

Methods

Data

Available data sources include spawn survey data, commercial catch landings data, and age composition data from biological samples of commercial fishery, pre-fishery charter, and research catches. These data are available in an Access database for the period 1951 to present coastwide with considerably fewer records for Area 9 specifically. Consistent with previous herring stock assessment documents, this time span includes the reduction fishery period to 1968 and the subsequent roe fishery period that began in 1972. Area 9 is divided into 3 management sections, Section 091 (Fish Egg Inlet), Section 092 (Goose Bay), and Section 093 (Head of Rivers Inlet) (Figure 2). Within each of these sections there is at least one major herring spawning bed. Spawn, catch and biological data usually are referenced to the Section within Area 9 where the observation/sampling was conducted.

Detailed documentation of the existing databases can be found in other stock assessment documents (e.g., Schweigert 2005) but it should be highlighted that of the three available data sets, the spawn data contain the largest measurement errors. While the quality of spawn surveys has generally improved over the course of the time series, due to increased effort and better quality control of the surveys, there are occasional problems with equipment and weather which may hamper data completeness or accuracy in some years. Since 1987 an increasing number of egg beds have been assessed using SCUBA rather than traditional surface survey methods and this observation is true for Area 9 as well. It is probable that the SCUBA surveys provide more accurate estimates of spawn but there are potential limitations. For example, it is recognized that some lesser spawns might go unsurveyed because effort was directed on identified herring spawns rather than searching for new ones. This would include spawns or potential spawns outside of the major assessment areas, including the minor herring assessment areas and other parts of the coast, including Area 9.

Methods used to estimate biomass based on various escapement models are presented in detail in Schweigert (2005). Briefly, spawning stock biomass can be estimated from the pre-fishery biomass estimated through spawn deposition and catch. However, it should be noted that forecasts of abundance for minor stocks are not possible at this time. In the absence of additional information it is assumed that the abundance of herring in the minor stock area in the coming season will be equivalent to that estimated in the previous season. This assumption does not capture trends in population dynamics nor can it account for strong or weak year classes entering or leaving the population.

Results

History of Spawning in Area 9

There are 75 years of available spawn observations for Area 9 herring but some of these years have no spawn observations for any Section (091, 092 or 093) (Tables 1 and 2). When these years are eliminated from the analyses, there are 68 years of available data (Table 1).

During the reduction fishery period up until the late 1960s herring biomass based on observed spawn was less than 1000 tonnes (Figure 3). Biomass generally increased in the early to mid 1970s but remained less than 2000 tonnes (Figure 3). Increased survey effort could have resulted in the increased observed biomass during this period. Biomass based on observed spawn was less than 1000 tonnes until 2002 when biomass increased but by 2005 this biomass had again decreased below 1000 tonnes (Figure 3). On average, biomass based on observed spawn in Area 9 is around 500 tonnes (Table 1). However, the median of this biomass is lower; around 260 tonnes (Table 1).

Generally, most of the observed herring spawn in Area 9 has occurred in Section 093 rather than Sections 092 or 091 as equal observations in spawn deposition have rarely occurred over the available time series (Figure 4). A weak positive correlation exists between the herring biomass in Section 093 and the biomass of herring in Section 092 based on the amount of herring spawn. However, it is unclear if herring consider Section

092 marginal and only use it when the stock size is high or if it is an artifact of the limited data available. There was no correlation between herring spawning biomass in Section 091 and Sections 092 or 093. Section 091 is outside of Rivers Inlet proper (Figure 2) and the herring spawning in this section might not represent the same body of fish spawning in Sections 092 or 093 within Rivers Inlet. However, additional genetic analyses would be required to address this hypothesis.

Within each of the Sections in Area 9 there are different spawning beds, one in Section 091, two in Section 092 and four in Section 093. Most of the herring biomass is associated with two beds, bed 11 in Section 093 (head of Rivers Inlet) and bed 11 in Section 092 (Goose Bay) (Figure 5). More recently, herring have been using bed 12 in Section 093 (Figure 5). It is unclear if this represents a shift in the herring spawning distribution or additional survey efforts on this bed in recent years. Herring spawning in nondescript beds (i.e., bed 99) has been minimal over the available time series (Figure 5) suggesting most spawning does occur on relatively well defined herring spawning beds. A pattern consistent with observations on major herring spawning beds coastwide.

History of Catch in Area 9

There are 55 years of available catch records for Area 9 herring but as with spawn, there were some years when no catches were reported from any Section (091, 092 or 093) (Tables 1 and 2). When these years are eliminated from the analyses, there are 24 years of data available (Table 1).

Reported catch of herring in Area 9 has been highly variable over time with almost all landings occurring during the reduction fishery period that ended in the late 1960s (Figure 6). During the reduction fishery period catches generally ranged between less than 500 tonnes to over 5000 tonnes per Section (Figure 6). During the early to mid 1970s there was a small increase in commercial herring catch from Area 9, primarily Section 093 but this was short lived as there was no reported catch after this time (Figure 6).

In general, most of the reported herring catch from Area 9 came from Section 091 or 093 rather than Section 092 (Figure 7). Considerable landings came from Section 091 during the reduction fishery period (Figure 7) which is consistent with interception of fish moving through this area. Positive correlations exist between the amount of herring caught in Sections 091 and 092 ($r=0.27$), between Sections 091 and 093 ($r=0.65$) and between Sections 092 and 093 ($r=0.57$). These correlations could be an artifact of increased search effort coaswide during the reduction fishery period.

Spawn and Catch Relationships

There were no significant correlations between the amount of herring spawn and the amount of herring caught at either the Section level or for all of Area 9 (sections combined). Furthermore, years with large herring catches in Area 9 were not correlated to years of high spawning biomass or time-lagged spawning biomass to account for

recruitment at age-3 (Figure 8). There are several possible explanations for this apparent discrepancy. First, and most probable, is that herring landed in Area 9 did not originate from Area 9. It is likely these were herring migrating to another part of the coast that happened to be intercepted in Area 9. This observation is consistent with practices employed during the reduction fishery period when most reported catch was landed. Also, it has been suggested that fishermen would often mis-report catch locations during the reduction fishery period but verifying this has proven extremely difficult. However, if true, this would explain the lack of correlation between biomass based on observed spawn and reported catch. It is probable that the observed spawn deposition was substantially underestimated, probably due to reduced effort and little coverage in this remote section of coast. However, it remains unclear if the biomass estimated from the observed spawn would be underestimated to such an extent as to make the catch data credible. Additional effort should be placed at resolving the precision of the biomass estimates based on observed spawn data but refining the accuracy of the catch records also should be attempted.

Biosampling Data for Area 9 Herring

There is little biosampling data available for this area. The number of herring sampled each year in Area 9, by Section, is shown in Table 3. Due to the highly variable nature of these data in space (sections) and time (years) making inferences about stock dynamics among sections or among years is not possible at this time. Also, increased biosampling data are required before an age-structured model could be developed. This is a lengthy process as insufficient age-structured data exist to complete such models for the minor herring stocks in BC that have been surveyed in considerably more detail than herring in Area 9.

DNA Analyses of Population Structure

Analyses of variation at microsatellite DNA has been used to detect population level differences in a variety of freshwater and marine organisms. The ability to detect putative populations using microsatellite DNA rather than allozymes or mitochondrial DNA has proven successful both for Pacific herring (O'Connell et al., 1998) and Atlantic herring (Shaw et al., 1999).

Beacham et al. (2001; 2002) used microsatellite DNA to detect putative population differences among different spawning aggregations of Pacific herring in British Columbia. They concluded there was little evidence to suggest genetically distinct herring stocks within the Central Coast management area. However, they suggested herring spawning in Rivers Inlet could be different from herring spawning within the CC major assessment area, especially herring spawning in the northern part of this area, but additional sampling was needed to confirm this suggestion (Beacham et al. 2002). Differences between Rivers Inlet herring and herring within the CC major stock assessment area were based on one year of sampling in Rivers Inlet (in 2001) and allele differences for 3 of the 10 microsatellite markers used.

Discussion

The available time series for herring in Area 9 is long, dating to the 1930s for spawn but also very patchy with many years of incomplete or missing data. This leads to considerable variability in both the herring spawn data and the herring catch data currently available for Area 9 and it is difficult to reconcile how much variability is due to inconsistent or sporadic observations in this area and how much is due to high population variability noted for short-lived marine fish such as herring. Consistent sampling in Area 9 would allow some resolution to the high variability observed, at least with respect to biomass based on observed spawn. Thus, establishment of a spawn survey design framework should be a high priority and should be identified prior to allowing harvest of herring in Area 9. Almost all of the herring catches reported from Area 9 were from the reduction fishery period and are not very useful for estimating the potential amount of herring utilizing this area or estimating potential harvest opportunities. It has been assumed that no reported catches of herring from Area 9 since the mid 1970s represents no fishing effort in this area rather than a lack of herring available for harvest. Furthermore, this data (and the available biosampling data) is not useful for inferring potential impacts of harvest on the stock.

Data quality is clearly an issue for herring in Area 9 with increased quality expected for the catch data but considerable uncertainty in the observed spawn data. No reported catches from Area 9 in recent years is consistent with no commercial fishery openings during this period. Spawn observations are inconsistent and highly variable over time. Although variability in herring spawn is expected, the available data are unable to provide any measure of effort, either for spawn detection or quantification. Improved data quality will be essential if harvest opportunities are to be entertained for Area 9 herring. Available data on putative populations in Area 9 remain unconfirmed. Initial analyses suggest that Area 9 herring could be distinct from the Central Coast major herring stock but this remains to be verified with additional analyses (Beacham 2002).

Catches from the major herring stocks during the reduction fishery period were often on the order of 40 000 tonnes per stock with substantially greater landings in many years, especially for the more productive stocks (Schweigert 2005). Harvest from the two minor herring stocks during the peak of the reduction fishery period also were highly variable and more consistent with the variable harvest reported for Area 9 (Figure 6; Schweigert 2005). However, given the interception nature of the reduction fishery it is unclear how much effort would have been directed at any of the minor herring stocks (recognized or potential). To remain cost effective, the reduction fishery would have targeted the largest aggregations of herring coastwide, even if they were young fish, and it is doubtful that much time would have been spent chasing herring around restricted locations like Area 2W, Area 27 or Area 9. Even if time was spent targeting herring in these more remote areas, it is still unknown if herring caught in these areas would represent herring that spawned in these areas. Interception fisheries do not readily allow discrimination of parental or spawning stock identity without additional analyses of the landed fish themselves (e.g., genetic determination of stock identification).

The current harvest policy for minor herring stocks in BC recommends a harvest of not more than 10% of the observed spawning stock biomass the previous year. The available data suggests herring biomass in Area 9 based on observed spawn deposition is around 500 tonnes and possibly around 260 tonnes when extreme observations are eliminated (Table 1). This is true even since the mid 1970s when the last reported herring catches were removed from Area 9 (Figure 7). Also, this low biomass estimate is generally lower than the other two minor herring stocks currently recognized in BC, Area 2W and Area 27, and substantially lower than the major stock assessment areas in BC (Schweigert 2005). However, as with all herring stocks in BC (major and minor) high variability in observed spawn is common. Given this high variability, it is difficult to recommend harvest opportunities be entertained in Area 9. Although this recommendation is inconsistent with the current harvest opportunities available for the two recognized minor herring stocks in BC, it is consistent with the PA.

The maintenance of population structure and substructure recently has been identified as a priority for all commercial fisheries. Thus, it is prudent to manage fisheries to ensure maintenance of the greatest potential biological and genetic diversity. The ability to accurately forecast herring stocks is a function of the spatial extent of the stock. Currently it is not possible to forecast biomass for smaller geographic regions than those used in the current BC major herring stock assessments and it is unlikely these smaller units would be accurate enough for fisheries management purposes (Schweigert 2005). Consistent with Schweigert (2005), fisheries should continue to focus on major herring aggregations within each assessment region to minimize the potential over-exploitation of any smaller, spatially discrete spawning groups. However, a scientifically defensible definition of a major herring aggregation is not available at this time. Similarly, there are no commercial (or conservation) fishery cutoff levels identified for any minor herring stock in BC. The commercial fishery cutoff levels identified for the major BC herring stocks were a function of the unfished stock biomass. There is insufficient data for the minor herring stocks to determine what the unfished stock size would be thereby confounding attempts to define cutoff levels for these minor aggregations of herring.

Currently, abundance for all minor herring stocks is based on observed spawn deposition. Given reduced effort (and hence coverage) in these minor areas, it is probable that biomass will be underestimated since some spawn is likely to go unobserved. However, it is not possible to identify how much spawn would go unreported or how much lower the estimated biomass would be from the actual (unknown) biomass. By default, this potential underestimate is precautionary and hence consistent with the PA. However, establishing fisheries based on highly variable biomass estimates will not lead to longer-term sustainability of the fishery itself, especially for minor assessment areas where biomass is substantially lower and potentially more variable over time.

Herring size-at-age has decreased since the early 1970s for all herring stocks in BC and many herring stocks around the world. Previous studies on inlet herring (Stevenson, 1950; Ware and Schweigert, 1994) have shown inlet fish usually are substantially smaller at age and can have slower growth rates than those belonging to the larger, migratory populations. It has been speculated that lower food resources in BC mainland inlets

prevents these fish from attaining sizes at age comparable to the migratory fish. Although this phenomenon in itself would not preclude harvesting inlet herring, it is one additional factor that should be considered when assessing biomass for inlet populations such as Area 9. Also, it is possible that an adjustment might be required to adjust the escapement methodology used for other BC herring stocks to an inlet stock.

Recommendations

Additional microsatellite DNA analyses should be undertaken to confirm the potential discreetness of Rivers Inlet herring. If interannual variability in allele frequencies is greater than the spatial variability, then it is possible Rivers Inlet herring could be considered part of the Central Coast major stock. However, if the spatial variability in allele frequencies is greater than the temporal variability there would be evidence to suggest Rivers Inlet herring are different from the Central Coast major stock and could be managed independently.

Since current harvest rules for minor herring stocks in BC is based on the amount of spawn observed the previous year, much greater consistency in spawn coverage needs to be obtained. A pre-determined area should be identified for spawn observations and data should be collected according to existing spawn survey standards. Standardization will be essential to allow meaningful comparisons in future years, especially if herring are harvested from Area 9. The limited data available suggest herring in Area 9 are using one major bed in Section 093 at the head of Rivers Inlet and another minor bed in Section 092 in Goose Bay. It appears the bed in Section 091 in Fish Egg Inlet has not been used for some time. Thus, the two beds in Sections 092 and 093 should be the highest priority for ongoing monitoring of spawn deposition to estimate spawning biomass. Ideally, the proposed genetic samples would be collected from fish spawning on these two beds to confirm they are the same but also distinct from adjacent populations.

A biosampling program must be initiated and maintained in Area 9 if harvest opportunities are entertained now or in the future. This basic data collection will be critical to evaluate any potential impacts of future harvest (e.g., fishing down age classes) and could be used to create a time series that might allow development of an age-structured model like the ones employed for the major herring stocks in BC.

References

Beacham, TD, JF Schweigert, C MacConnachie, KD Le, K Labaree and KM Miller. 2001. Population structure of herring (*Clupea pallasi*) in British Columbia: an analysis using microsatellite loci. DFO Can. Sci. Advis. Sec. Res. Doc. 2001/128.

Beacham, TD, JF Schweigert, C MacConnachie, KD Le, K Labaree and KM Miller. 2002. Population structure of herring (*Clupea pallasi*) in British Columbia determined by microsatellites, with comparisons to southeast Alaska and California. DFO Can. Sci. Advis. Sec. Res. Doc. 2002/109.

FAO. 1995. Precautionary approach to fisheries. Part 1: Guidelines on the precautionary approach to capture fisheries and species introductions. FAO Fisheries Technical Paper 350(1).

Haegele, CW and LC Fizpatrick. 1983. The distribution of herring spawn and associated roe fisheries in British Columbia (1976 to 1980). Canadian Data Report of Fisheries and Aquatic Sciences 407: 250 pp.

O'Connell, M, MC Dillon, JM Wright, P Bentzen, S Merkouris and J Seeb. 1998. Genetic structuring among Alaskan Pacific herring populations identified using microsatellite variation. Journal of Fish Biology 53: 150-163.

Schweigert, J. 2005. An assessment framework for Pacific herring (*Clupea pallasi*) stocks in British Columbia. DFO Can. Sci. Advis. Sec. Res. Doc. 2005/083.

Shaw, PW, C Turan, JM Wright, M O'Connell and GR Carvalho. 1999. Microsatellite DNA analysis of population structure in Atlantic herring (*Clupea harengus*), with direct comparison to allozyme and mtDNA RFLP analyses. Heredity 83: 490-499.

Stevenson, JC. 1950. Growth of herring along the upper East coast of Vancouver Island. Fisheries Research Board of Canada Pacific Progress Report.

Therriault, TW and DE Hay. 2005. Surf smelt (*Hypomesus pretiosus*) in Burrard Inlet, British Columbia: a limited data assessment to address concerns about potential recreational overharvesting. Fisheries Assessment and Management in Data-Limited Situations. Alaska Sea Grant College Program. AK-SG-05-02: 901-917.

Ware, DM, JF Schweigert. 1994. Growth and mortality rates of British Columbia minor herring stocks. Pacific Stock Assessment Review Committee Working Paper H94-6.

Table 1: Summary of Area 9 herring data including biomass based on observed spawn and reported catch.

	N	Mean (tonnes)	Median (tonnes)	Minimum (tonnes)	Maximum (tonnes)	Std. Dev.
Spawn Sec. 091	75	21.8		0.0	308.0	62.7
Spawn Sec. 092	75	98.1	9.8	0.0	900.7	199.7
Spawn Sec. 093	75	341.9	152.4	0.0	2693.5	513.8
Spawn Area 9	75	461.7	231.8	0.0	3427.9	599.6
Catch Sec. 091	55	383.6		0.0	5229.6	1061.9
Catch Sec. 092	55	64.8		0.0	620.1	151.2
Catch Sec. 093	55	391.2		0.0	2660.4	722.4
Catch Area 9	55	843.5		0.0	3059.1	1703.1
		With zero catch and spawn records removed				
Spawn Sec. 091	16	102.0	83.6	4.1	308.0	103.1
Spawn Sec. 092	43	171.1	60.9	0.7	900.7	239.7
Spawn Sec. 093	64	400.7	196.1	4.1	2693.5	535.0
Spawn Area 9	68	509.3	262.7	4.9	3427.9	610.4
Catch Sec. 091	13	1622.9	781.1	85.2	5229.6	1701.7
Catch Sec. 092	16	222.6	133.9	11.4	620.1	211.6
Catch Sec. 093	23	935.4	654.8	41.5	2660.4	865.3
Catch Area 9	24	1933.0	910.3	41.5	7985.2	2147.6

Table 2: Biomass based on observed spawn and reported catch for each of the herring sections in Area 9.

	Biomass based on Spawn (mt)			Reported Catch (mt)		
Year	091	092	093	091	092	093
1931	0	0	0			
1932	0	0	0			
1933	0	0	0			
1934	0	0	0			
1935	0	0	0			
1936	0	0	0			
1937	0	0	37.35			
1938	0	0	25.94			
1939	0	20.75	41.37			
1940	0	0	44.98			
1941	0	10.38	215.88			
1942	308	0	7.37			
1943	0	83.04	296.97			
1944	5.31	6.37	305.84			
1945	85.86	12.74	194.21			
1946	11.8	92.84	137.4			
1947	0	89.01	157.85			
1948	11.8	23.59	161.84			
1949	155.37	60.86	8.22			
1950	4.09	1.65	0			
1951	0	147.19	20.44	0	0	694.915
1952	0	28.27	44.12	0	0	498.96
1953	0	9.81	317	0	0	0
1954	0	0	25.21	85.246	0	2101.982
1955	0	0	136.96	2967.756	92.534	2157.167
1956	0	0	88.23	0	29.938	103.965
1957	53.01	0	4.09	1003.659	558.109	1502.323
1958	152.37	334.19	36.68	119.833	172.595	57.852
1959	84.43	6.55	140.85	750.705	311.968	1653.363
1960	0	14.74	105.45	0	51.71	199.43
1961	0	0.73	9.05	348.334	0	669.114
1962	295.21	594.15	225.41	3981.044	27.216	654.772

1963	236.29	22.91	8.16	2967.321	85.73	782.687
1964	0	116.4	561.42	5229.57	95.256	2660.346
1965	127.63	0	317.65	781.069	58.061	532.889
1966	0	83.94	336.65	2393.617	620.071	2438.998
1967	82.81	57.08	633.57	328.376	552.938	1911.733
1968	0	235.7	287.64	0	0	41.504
1969	0	32.35	198	0	0	0
1970	0	159.83	890.46	0	0	0
1971	0	578.31	639.35	0	204.846	0
1972	0	554.45	741.92	141.566	452.796	208.832
1973	0	287.01	933.93	0	0	1702.585
1974	0	7.03	728.11	0	236.558	500.56
1975	0	609.05	1367.2	0	11.435	85.862
1976	0	13.1	726.68	0	0	298.472
1977	0	27.81	1200.01	0	0	56.497
1978	0	15.48	535.14	0	0	0
1979	11.16	124.06	9.11	0	0	0
1980	0	0	258.08	0	0	0
1981	7.49	108.65	69.74	0	0	0
1982	0	0	98.53	0	0	0
1983	0	10.51	0	0	0	0
1984	0	0	110.54	0	0	0
1985	0	0	107.48	0	0	0
1986	0	0	152.42	0	0	0
1987	0	0	138.48	0	0	0
1988	0	37.42	162.35	0	0	0
1989	0	0	119.42	0	0	0
1990	0	0	501.12	0	0	0
1991	0	0	351.78	0	0	0
1992	0	210.64	679.17	0	0	0
1993	0	152.1	181.76	0	0	0
1994	0	0	758.57	0	0	0
1995	0	0	0	0	0	0
1996	0	0	876.47	0	0	0
1997	0	0	4.85	0	0	0
1998	0	0	221.49	0	0	0
1999	0	0	231.84	0	0	0
2000	0	900.73	0	0	0	0

2001	0	710.77	0	0	0	0
2002	0	0	1930.82	0	0	0
2003	0	0	2305.81	0	0	0
2004	0	734.32	2693.53	0	0	0
2005	0	28.57	785.26	0	0	0

Table 3: Summary of records from the biosampling database by year and herring section within Area 9.

	Section		
Year	091	092	093
1950			300
1951			200
1953	200		700
1954	579	395	1089
1955	100	200	100
1956			1150
1957	150	450	
1958	50	250	550
1959	50		100
1960		50	100
1961	100		200
1963			150
1964	140	50	30
1965	150		50
1971		200	
1972		100	100
1973		74	300
1974			300
1975	295	248	397
1976			199
1977			87
1980			200
1981	100		100
1988	200	200	
1989		100	
1990			100
1996		300	218
1997		200	100
2001			100
2002		200	100
2003		296	
2004		300	
2005			100

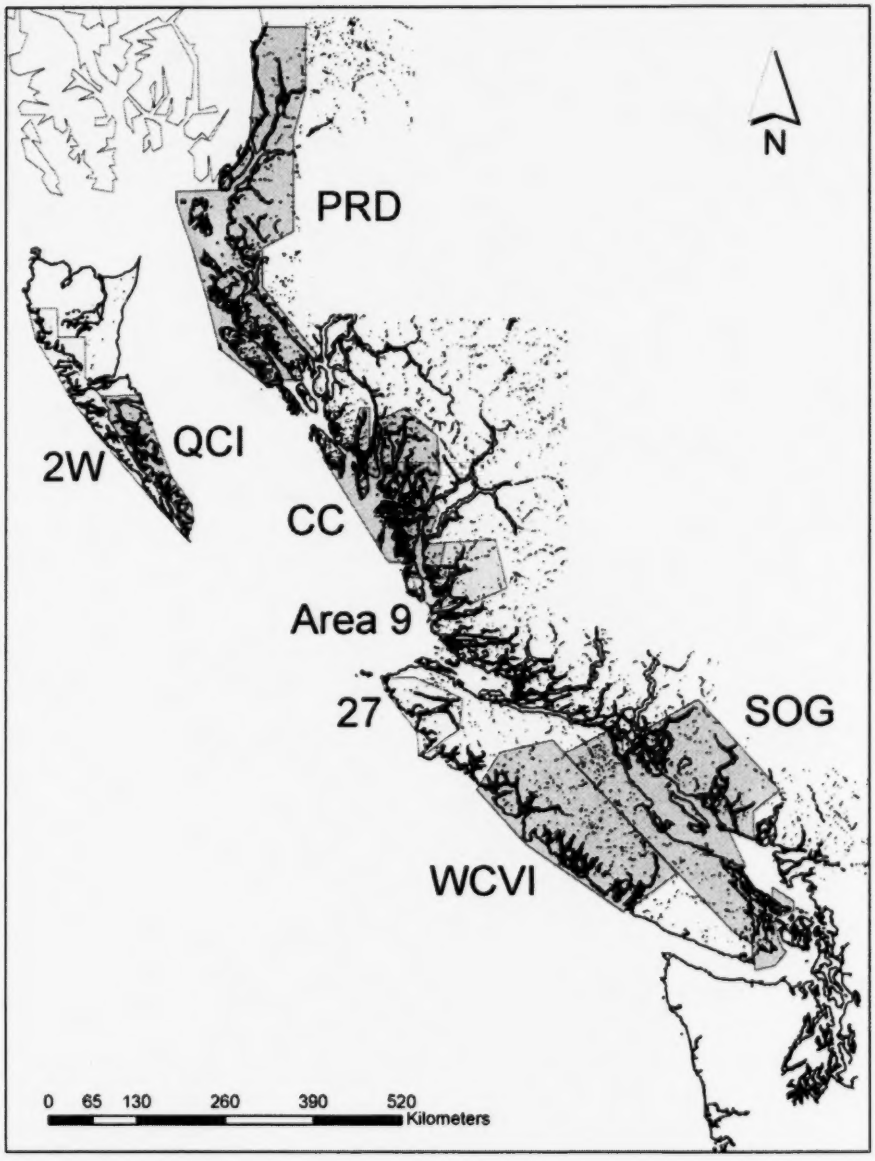

Figure 1: The five major herring stock management areas: Queen Charlotte Islands (QCI), Prince Rupert District (PRD), Central Coast (CC), Strait of Georgia (SOG) and West Coast Vancouver Island (WCVI) are shown. In addition, the two minor stock assessment areas are currently recognized: Area 2W and Area 27 and are shown. The Area 9 assessment area also is shown.

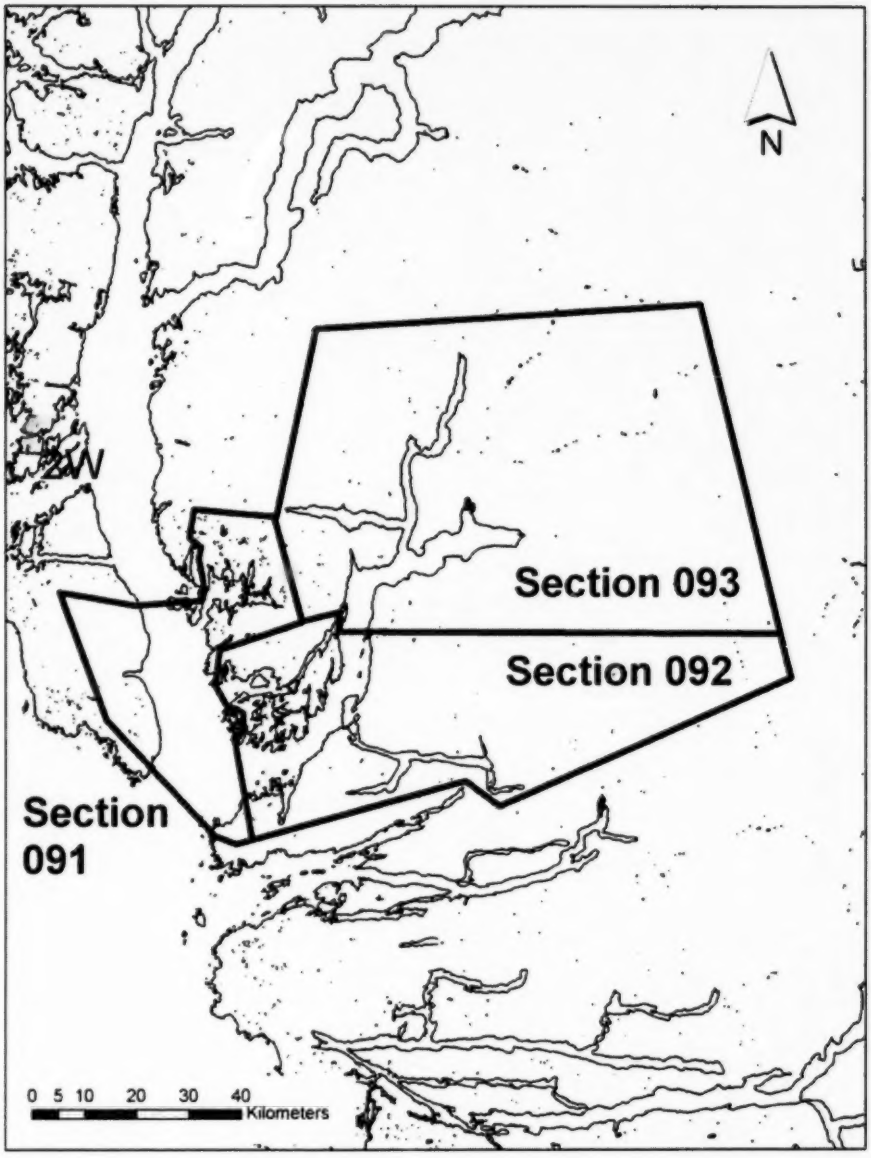

Figure 2: Herring management sections in Area 9: Section 091 (Fish Egg Inlet), Section 092 (Goose Bay) and Section 093 (Head of Rivers Inlet).

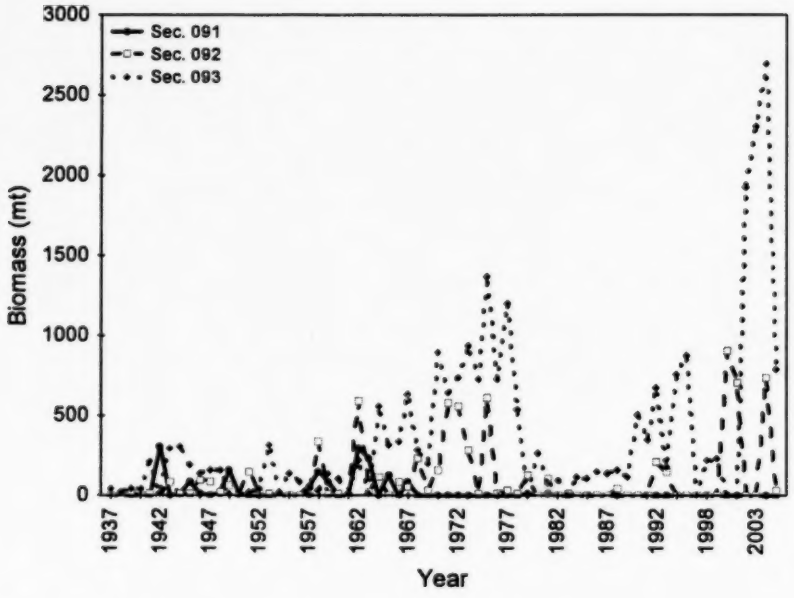

Figure 3: Time series of herring biomass in Area 9 based on observed spawn deposition.

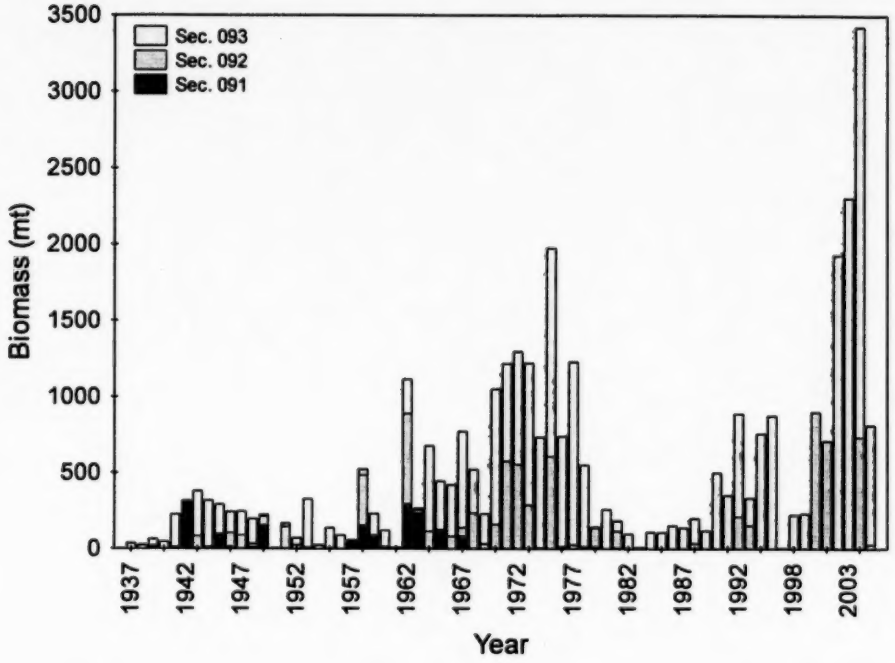

Figure 4: Distribution of biomass based on observed spawn in Area 9 showing the relative contribution from each of the three herring sections.

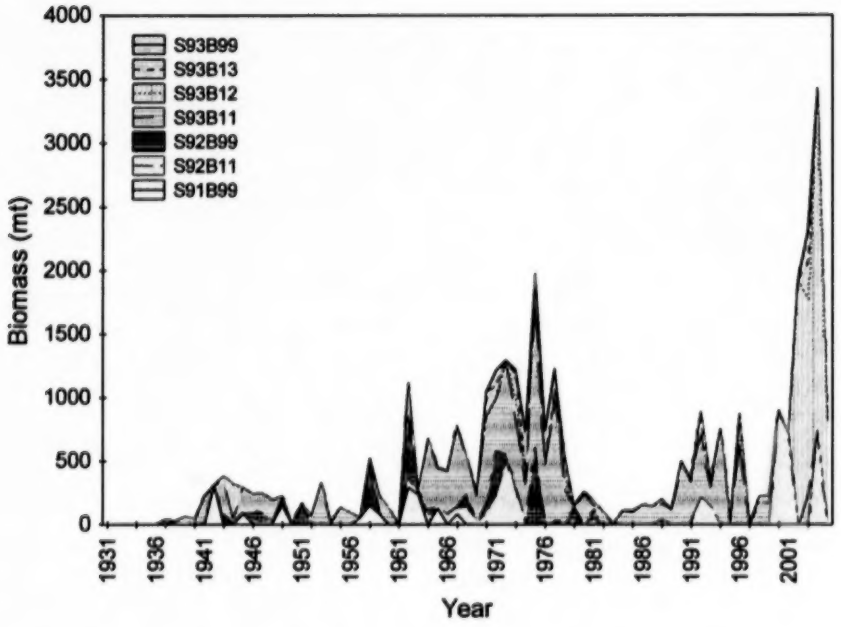

Figure 5: Distribution of herring biomass by section (S) and spawning bed number (B) in Area 9. Bed number 99 refers to all spawn not associated with a major herring spawning bed.

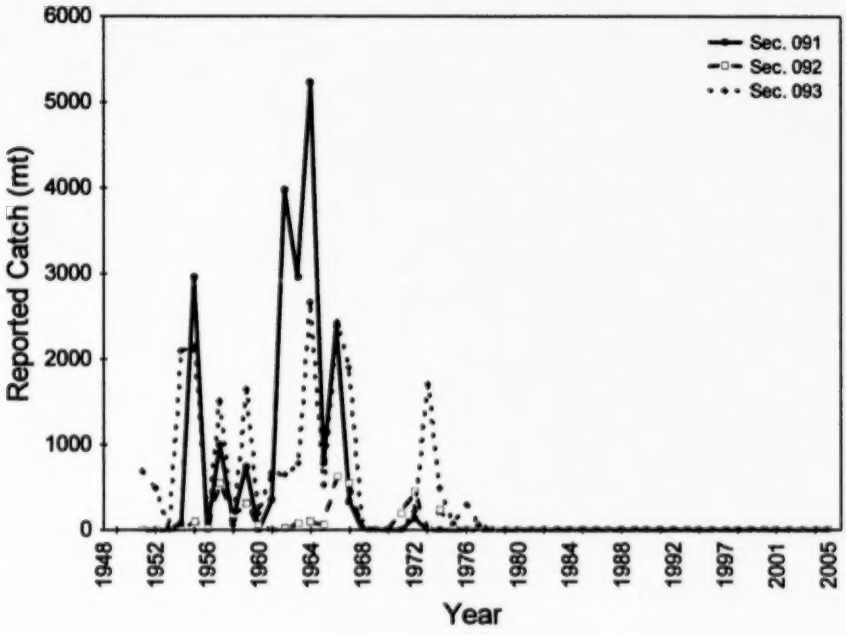

Figure 6: Time series of herring catches in Area 9.

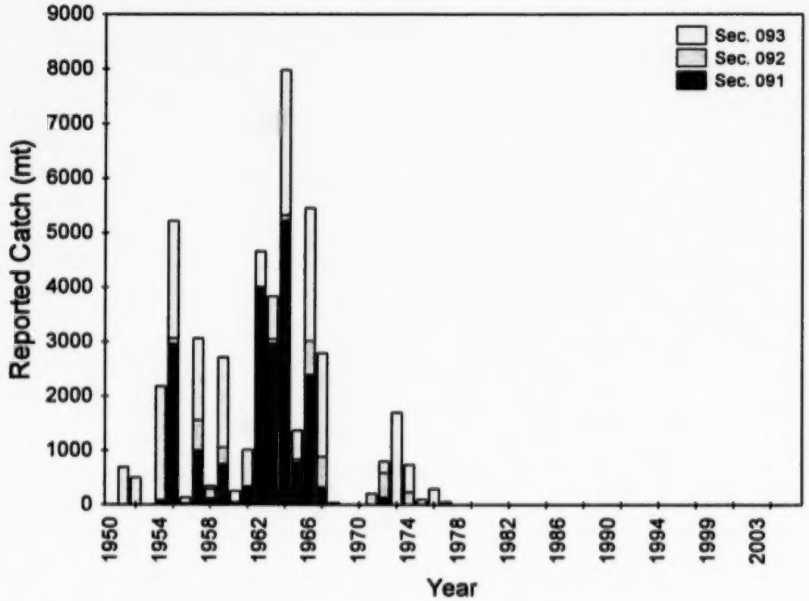

Figure 7: Distribution of herring catches in Area 9 showing the relative contribution from each of the herring sections.

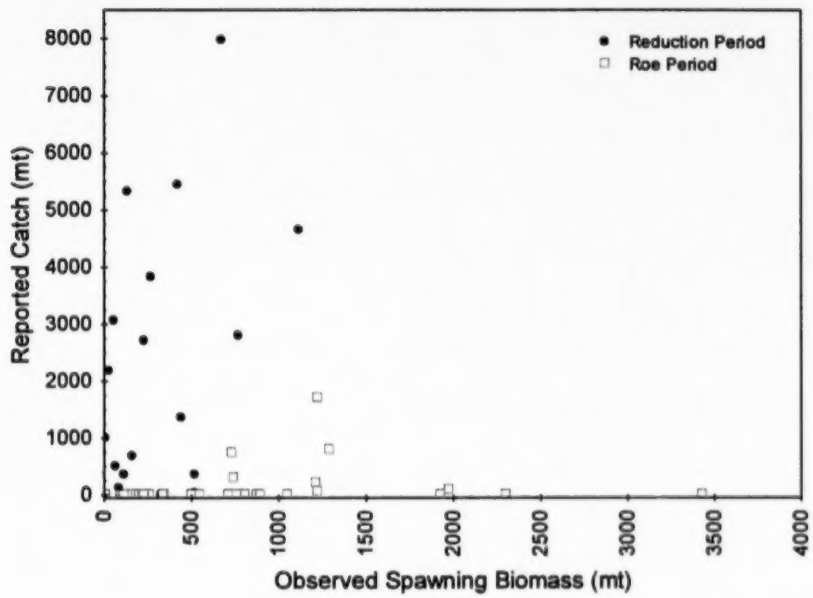

Figure 8: Relationship between biomass based on observed spawn deposition and reported herring catches from Area 9. The reduction period and roe period are indicated.

Appendix 1: PSARC Request for Working Paper (RFWP)

PSARC Request for Working Paper

Date Submitted: December 7, 2005

Individual or group requesting advice: First Nation / Fisheries Manager

Proposed PSARC Presentation Date: May.

Subject of Paper (title if developed):
A review of stock assessment information for Area 9 herring

Stock Assessment Lead Author: Tom Therriault

Fisheries Management Author/Reviewer: Steven Groves

Rationale for request:
(What is the issue, what will it address, importance, etc.)

The Wui'kinuxv First Nation has requested a herring SOK harvest opportunities in Area 9. The Area 9 is outside of the Central coast major assessment area and currently supports a biomass of spawning herring which is not exploited. However, it is unclear how abundant to how variable this biomass is from year to year.

Thus, it was recommended that a review of the available biological data in this area be completed to determine if the spawning abundance of herring in Area 9 is sufficient to support a sustainable level of harvest.

Question(s) to be addressed in the Working Paper:
(To be developed by initiator)

Questions to be addressed:

1. Is there evidence to support the definition of Area 9 herring as a distinct minor stock for which a TAC can be established?
2. If so, is there adequate biological information to assess the average level of spawning biomass in the area and its interannual variability?
3. What are the deficiencies / limitations of the historic data time series?
4. Is the available time series of historic data adequate to define a sustainable level of harvest for Area 9
5. What biological data needs to be collected to monitor the status of the herring resource in Area 9 on an ongoing basis?
6. What would be the biological impact of harvesting herring in Area 9, and what future stock assessment activities would be required to identify longer term impacts?

Objective of Working Paper:
(To be developed by FM & StAD for internal papers)
A PSARC review of biological data pertaining to the herring spawning population in Area 9 needs to conducted to evaluate whether these fish can be considered a distinct minor stock. If Area 9 herring can be defined as a minor BC herring stock, a process for assessing abundance and determining a sustainable harvest levels in the area needs to be defined. The process for assessing abundance would be consistent with that for other minor herring stocks.

Stakeholders Affected: Roe herring industry, spawn-on-kelp industry, First Nations and local communities.

How Advice May Impact the Development of a Fishing Plan:

Based on the outcome of the analysis, information may be used to set a TAC for area 9 as a minor stock assessment area. If warranted, an exploitable allocation may be available..

Timing ***Issues Related to When Advice is Necessary***

Advice by the next PSARC meeting has been committed.

Appendix 2: Response to Questions Posed in PSARC RFWP

1. Available genetic information suggests potential differences exist between Area 9 herring and CC herring. However, this needs to be confirmed. Also, to be consistent with the PA, additional stock assessment data needs to be collected and evaluated before a TAC is considered. Available spawn data do not allow resolution of stock structure or how putative stock(s) in Area 9 are using the available habitat.

2. Limited spawn information suggests an average of 500 tonnes and a median of about 260 tonnes of herring in Area 9 (Table 1). However, there is considerable variability around these estimates. It is not possible to identify a consistent biomass estimate for Area 9 at this time.

3. Deficiencies and limitations of the available data are outlined above. Based on available data it is not possible to identify stock structure or dynamics at this time.

4. The current data do not permit identification of a sustainable level of harvest for Area 9. There is no correlation between the available catch and spawn data with many years of landings well in excess of escapement biomass estimates.

5. To evaluate the herring biomass in Area 9 in a scientifically defensible way, spawn surveys need to be conducted to determine current stock biomass. In addition, biosampling information needs to be collected to determine population structure. If harvest opportunities are provided then detailed catch monitoring should be implemented.

6. It is impossible to predict the impact of potential harvest in Area 9 with the data currently available. To identify longer-term impacts of harvesting, DNA analyses should be conducted on a routine basis to ensure genetic population structure is not eroded by harvesting activities. Age classes should be monitored to ensure representation of older age-classes in the population and that the age structure of the population does not become truncated by harvesting. Also, recruitment needs to be monitored to ensure it is not impacted by harvesting or that harvesting causes a shift in maturation schedules. The impact on non-target species, either directly or indirectly, remains unknown. Predicting the impacts of harvesting for any species has proven virtually impossible to date.